MOTION IMAGERY STANDARDS BOARD **RECOMMENDED PRACTICE** **Parallel Interface for Infrared Motion Imagery**	**MISB RP 0402.6** **27 February 2014**

1 Scope

In this document five infrared image signal structures and a synchronous parallel interface for infrared motion imagery are defined. Bit word depth from 8-bits up to 16-bits at a clock frequency of 27.027 MHz, 27 MHz and 74.25 MHz are supported. All of the image structures are based on a progressive scan operating at 60 or 50 Hz frame frequency.

The supported image signal structures operating at 60 Hz frame rate are:

- 640 pixels x 480 lines
- 720 pixels x 480 lines
- 1280 pixels x 720lines

And at 50 Hz frame rate image structures supported are:

- 720 pixels x 576 lines
- 1280 pixels x 720 lines

2 References

2.1 Normative References

The following references and the references contained therein are normative.

[1] SMPTE ST 291-1:2012, Ancillary Data Packet and Space Formatting

2.2 Informative References

[2] MISB ST 0403 Digital Representation and Source Interface formats for Infrared Motion Imagery mapped into 1280x720 format Bit-Serial Digital Interface, Feb 2014
[3] Uncooled B-Kit Specification and Interface Control Document, Army PM NV- RSTA, 2004
[4] SMPTE ST 296: 2012, 1280x720 Progressive Image 4:2:2 and 4:4:4 Sample Structure – Analog and Digital Representation and Analog Interface

3 Revision History

Revision	Date	Summary of Changes
RP 0402.6	02/27/2014	• Changed name to match document content • Updated format including EARS

4 Acronyms

ANC Ancillary Data Space
EAV End of Active Video
SAV Start of Active Video

5 Introduction

The IR image signal structure of the interface signal, its synchronization, and as it appears on the parallel output interface is defined. Parallel output interface is rarely used as a transmission of the signal over longer distances; however, its usefulness is in connecting various processing blocks within or between equipment.

The IR image signal structures are based on 27 MHz (27.027 MHz) and 74.25 MHz sample clock frequencies. These frequencies are direct derivatives of those used in Standard and High-Definition television; thus, these IR structures may be compatible with commercial television equipment.

This document establishes the digital dynamic range for various data word depths (8 to 16 bits), so the resulting signal from a lower bit-depth interface may operate in the same range as a signal from a higher bit-depth interface. This is achieved by establishing a common lowest reference level (“black level”) and a highest reference level (100% level) for all images, regardless of their bit-depth quantization.

This document complements MISB ST 0403[2] that specifies the use of a serial interface for the IR systems described in this document. The parallel output of the interface described in this document is directly compatible to the input interface of the serial interface described in ST 0403.

6 Sampling Structures

Formats for sampled infrared image structures (raster) with their associated clocking frequency are shown in Table 1. Accordingly, total data rate on the interface is as indicated in Table 1.

Table 1: Infrared Motion Imager Structures

System	Active Image lattice	Frame Rate (Hz)	Number of lines per frame	Number of total samples per line	Number of active samples per line	Pixel sample clock (MHz)	Data rate at 16 bit depth
1	640 x 480	60	525	858	640	27.027	432.432 Mb/s
2	720 x 480	60	525	858	720	27.027	432.432 Mb/s
3	720 x 576	50	625	864	720	27.0	432 Mb/s

4	1280 x 720	60	750	1650	1280	74.25	1.188 Gb/s
5	1280 x 720	50	750	1980	1280	74.25	1.188 Gb/s

Requirement	
RP 0402.6-01	The bits of the digital data words that describe the infrared signal shall be transmitted in a parallel arrangement using sixteen conductor pairs as individual digital words with appropriate bit depth.
RP 0402.6-02	All synchronizing signals shall be detected by reference only to the eight (8) most significant bits with the remaining bits discarded.

A seventeen conductor pair carries a clock signal at associated clock frequency. The interface allows the transmission of appropriate ancillary signals that may be multiplexed into the data stream during infrared signal blanking.

7 General Considerations

7.1 Compliance Requirement

The specification of a system in compliance with this document should indicate the following:

- The IR systems/structures of Table 1 that are implemented
- Signal processing implemented (transfer function, filtering, or other process)
- Whether the digital representation employs uniformly quantized (linear) PCM
- The number of bits on the parallel interface

Note: It is not necessary to support all structures and formats and/or a 16 bit bus structure for an implementation to be compliant with this document.

7.2 Sampling frequency tolerance

Requirement	
RP 0402.6-03	The Interface sampling frequency shall be maintained to a tolerance of ± 10 ppm.

8 Raster Structure

Lines are numbered in time sequence according to the raster structure described in this section.

8.1 Sample sequence and line numbering

Requirement	
RP 0402.6-04	Pixel representation at the interface shall be presented from left to right horizontally and in lines from top to bottom vertically.

8.2 Line sequence in progressive scanning

Requirement	
RP 0402.6-05	A progressive frame shall comprise the indicated total number of lines per frame in order from top to bottom.
RP 0402.6-06	Each line at the interface shall be of equal duration determined by the interface sampling frequency and samples per total line (S/TL) for a given IR system.

The time difference between any two adjacent sample instants is called the reference clock interval T.

8.3 Vertical raster structure (vertical blanking)

Requirement	
RP 0402.6-07	The raster structure in the vertical direction and vertical ancillary space (VANC) for IR systems 1 through 5 shall be as indicated in MISB RP 0402.6 Table 2 and Figure 1, Figure 2, and Figure 3.

Table 2: Vertical Raster Structure for IR Systems 1 - 5

IR System	Active Image Raster	Number of lines per frame	Vertical blanking lines #	Blank (empty) lines #	Active Image lines #
1	640 x 480	525	1 thru 42 incl.	43; 524; 525	44 thru 523 incl.
2	720 x 480	525	1 thru 42 incl.		
3	720 x 576	625	1 thru 44 incl. 621 thru 625 incl.	NA	45 thru 620 incl.
4	1280 x 720	750	1thru 25 incl. 746 thru 750 incl.	NA	26 thru 745 incl.
5				NA	

Note: Content of Blank (empty) lines are set to a level corresponding to 0% signal level as related to a relevant bit code as shown in Table 8. (E.g. for an 8-bit A/D conversion, the level is set to 10h).

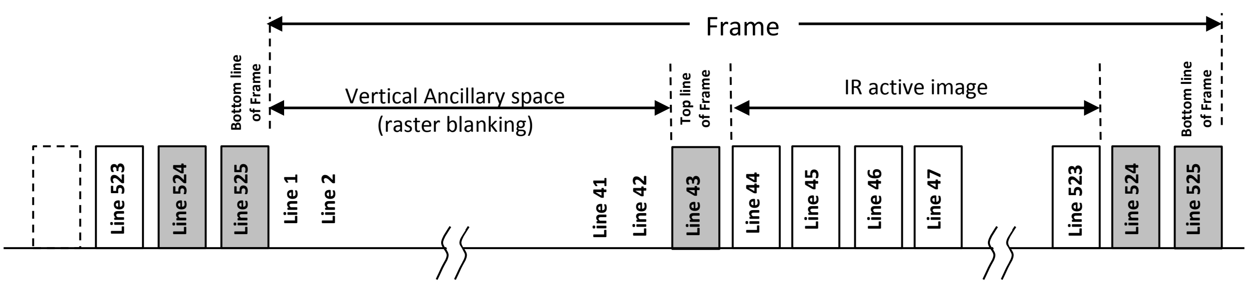


Figure 1: Vertical blanking for IR system 1 and 2 (525 lines system)

Note: Lines shown in dark do not contain image data and the code is set to 10h.

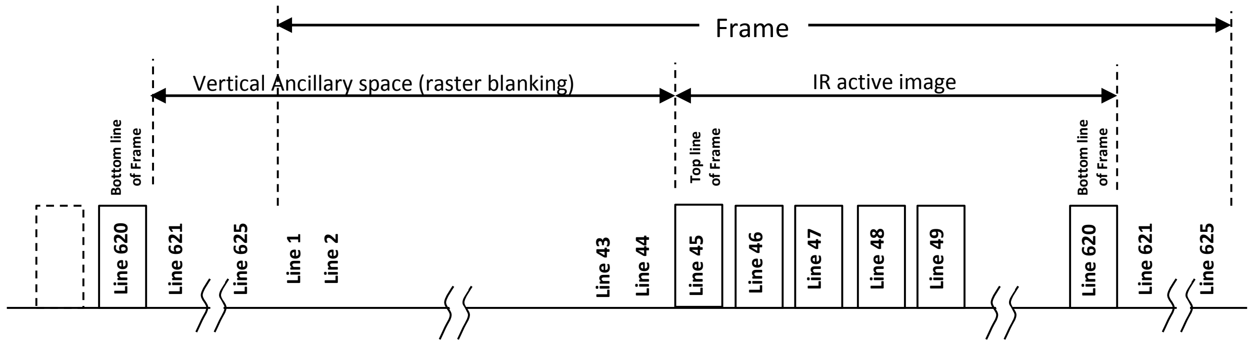


Figure 2: Vertical blanking for IR system 3 (625 lines system)

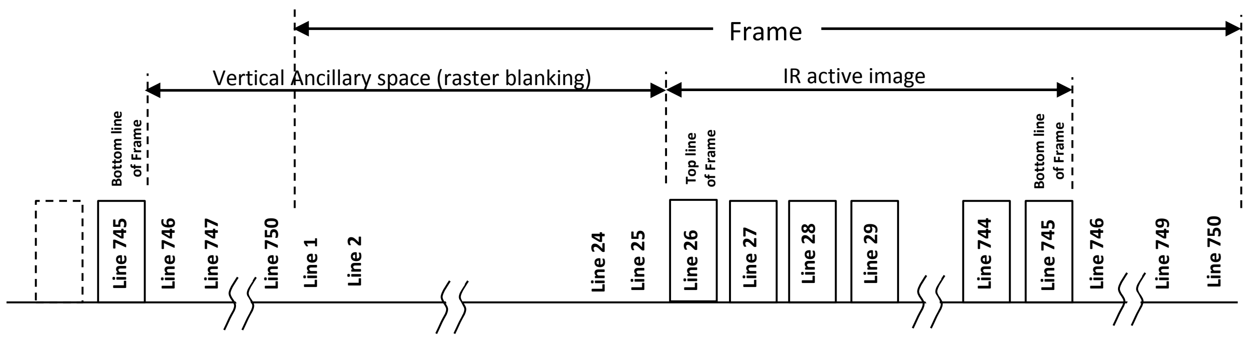


Figure 3: Vertical blanking for IR system 4 and 5 (750 lines system)

8.4 Horizontal raster structure (horizontal blanking)

Requirement	
RP 0402.6-08	The raster structure in horizontal direction for IR systems 1 through 5 shall be as indicated in MISB RP 0402.5 Table 3 and Figure 4, Figure 5, and Figure 6.

Table 3: Horizontal Raster Structure for IR system 1 - 5

IR system	Active Image raster	# of words per line	# of active image words per line	# of blank (empty) words per line	# of horizontal Ancillary words per line
1	640x480	858	640	80	130
2	720x480	858	720	NA	130
3	720x576	864	720	NA	136
4	1280x720	1650	1280	NA	362
5	1280x720	1980	1280	NA	692

Note: Content of Blank (empty) words in a line are set to a level corresponding to 0% signal level as related to a relevant bit code as shown in Table 8. (E.g. for an 8-bit A/D conversion, the level is set to 10h)

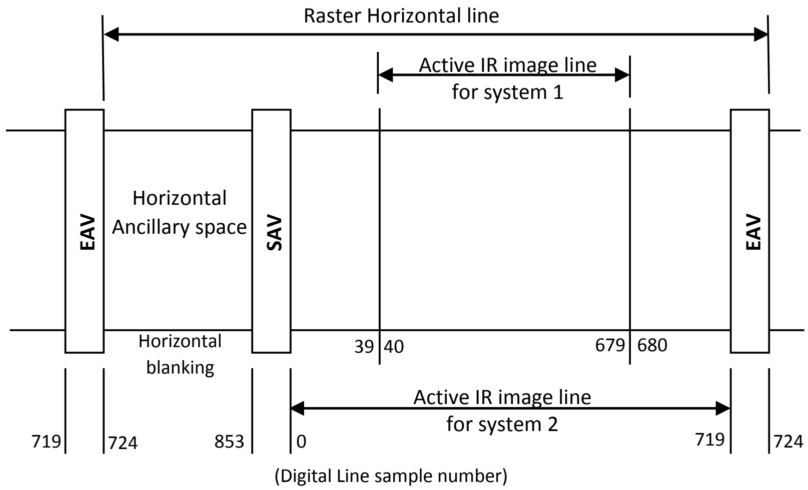


Figure 4: Raster horizontal line structure for IR system 1 and 2 (640x480 and 720x480)

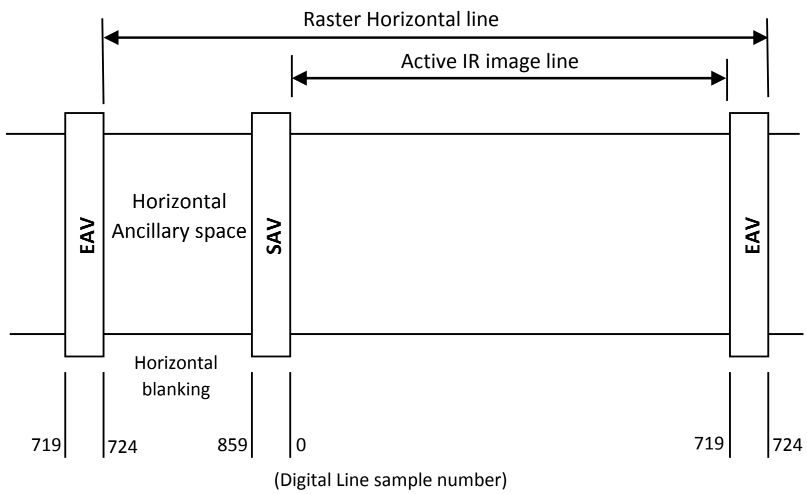


Figure 5: Raster horizontal line structure for IR system 3 (720x576)

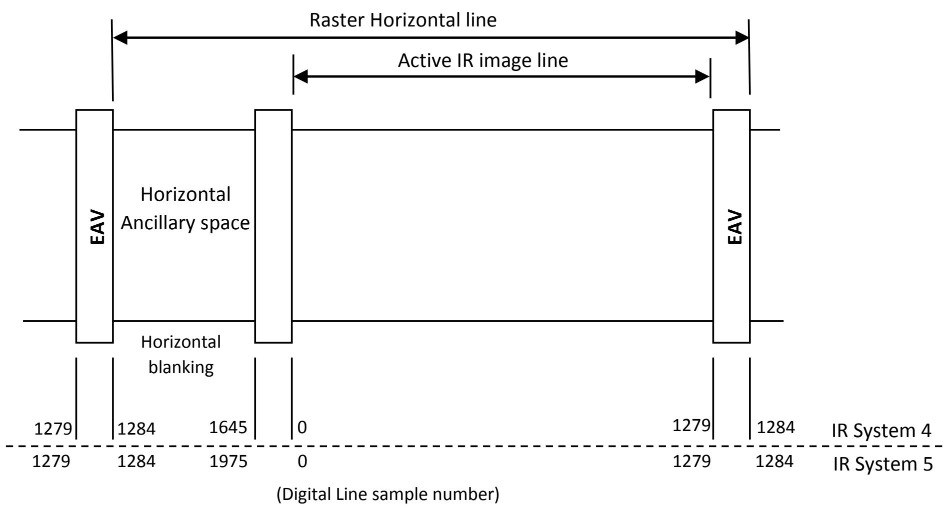


Figure 6: Raster horizontal line structure for IR system 4 and 5 (1280x720)

Table 4: Sample numbering for a Horizontal line of a 1280 x 720 system

IR system	Frame freq.	Sample number											
		a	**b**	**c**	**d**	**e**	**k**	**l**	**m**	**n**	**o**	**p**	**a**
1	60 Hz	720	721	722	723	724	854	855	856	857	0	719	720
2	60 Hz	720	721	722	723	724	854	855	856	857	0	719	720
3	50 Hz	720	721	722	723	724	860	861	863	863	0	719	720
4	60Hz	1280	1281	1282	1283	1284	1646	1647	1648	1649	0	1279	1280
5	50 Hz	1280	1281	1282	1283	1284	1976	1977	1978	1979	0	1279	1280
		EAV				ANC space	SAV				Active video line		
		A horizontal line											

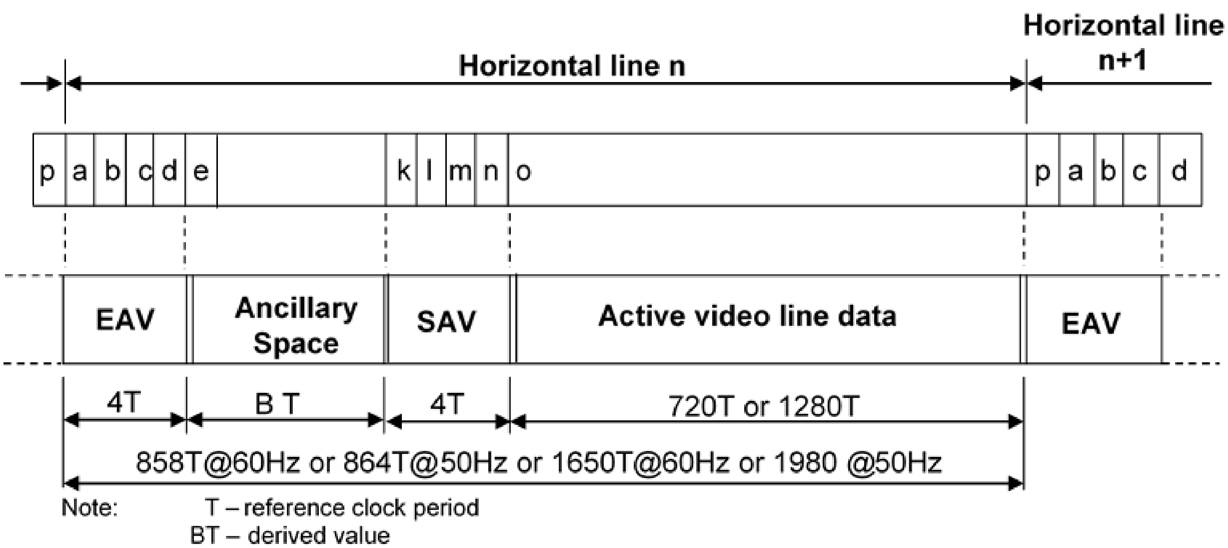


Figure 7: Horizontal timing of a digital stream for IR system 1 - 5

8.5 IR image aspect ratio

Requirement	
RP 0402.6-09	The image aspect ratio of an image in IR Systems 1, 2, and 3 as specified in MISB RP 0402.6 Table 4 shall be 4:3.
RP 0402.6-10	The image aspect ratio of an image in IR Systems 4 and 5 as specified in MISB RP 0402.6 Table 4 shall be 16:9.

9 Synchronizing words (timing and reference signals)

9.1 Synchronizing words and protection codes

The parallel interface is a synchronous interface and carries the synchronizing words (timing and reference signals) in a specific pattern along the parallel data stream.

The position of the timing reference signals (SAV – Start of Active Video, EAV – End of Active Video) with respect to horizontal blanking data stream is shown in Figure 4, Figure 5 and Figure 6. It is implicit that the timing reference signals are contiguous with the IR image data when present, and continue through the vertical blanking interval. Each timing reference signal consists of a four-word sequence in the following format:

- 8 bit: FFh – 00h – 00h – XYZh
- 10 bit: 3FFh – 000h – 000h – XYZh
- 12bit: FFFh – 000f – 000h – XYZh
- 14 bit: 3FFFh – 0000h – 0000h – XYZ0h
- 16 bit: FFFFh – 0000h – 0000h – XYZ0h

Requirement	
RP 0402.6-11	All values in the relevant protected ranges shall be considered equivalent to 00h and FFh.
RP 0402.6-12	The fourth XYZh word shall contain information defining state of vertical blanking and horizontal blanking.

Because of various bit depth equipment (see Table 4 and Table 5), for detection purposes, all values in the relevant protected ranges should be considered equivalent to 00h and FFh. The first three words of the synchronizing word are a fixed preamble.

Assignment of bits within the fourth word is shown in Table 4.

Requirement	
RP 0402.6-13	A SAV sequence shall be identified by H= 0.
RP 0402.6-14	An EAV sequence shall be identified by H= 1.
RP 0402.6-15	In a progressive system the F bit shall be always set to 0.

In a progressive system the V bit changes its state during vertical blanking on the first line following the ”Bottom Line of a frame” as shown in Figure’s 1-3 for all IR system. P0, P1, P2, and P3 (parity bits) have states dependent on states of bits F, V, and H according to Table 5.

Requirement	
RP 0402.6-16	Because various bit depths of words can be transmitted, all synchronizing signals shall be detected only to the eight most significant bits.

The remaining lower order bits are discarded.

Table 5: Timing Reference codes and Protection bits for SAV and EAV for 8 to 16 bit words

Bit number		$b_{(n-1)}$ (MSB)	$b_{(n-2)}$	$b_{(n-3)}$	$B_{(n-4}$	$b_{(n-5)}$	$b_{(n-6)}$	$b_{(n-7)}$	$b_{(n-8)}$
Word									
0		1	1	1	1	1	1	1	1
1		0	0	0	0	0	0	0	0
2		0	0	0	0	0	0	0	0

3		1 (fixed)	F	V	H	P3	P2	P1	P0
		1	0	0	0	0	0	0	0
		1	0	0	1	1	1	0	1
		1	0	1	0	1	0	1	1
		1	0	1	1	0	1	1	0

Bit number continue		$b_{(n-9)}$	$b_{(n-10)}$	$b_{(n-11)}$	$b_{(n-12)}$	$b_{(n-13)}$	$b_{(n-14)}$	$b_{(n-15)}$	$b_{(n-16)}$ (LSB)
0		1	1	1	1	1	1	1	1
1		0	0	0	0	0	0	0	0
2		0	0	0	0	0	0	0	0

3		1 (fixed)	F	V	H	P3	P2	P1	P0
		1	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0

Where: $8 \leq n \leq 16$ for words 1 through 3
H = 1 for EAV
H = 0 for SAV
V = 1 during active raster where IR image may be located
V = 0 during vertical blanking of the IR signal raster

An error detection and correction states in the received timing reference signal is given in Annex B.

9.2 Protected word range

Because of multiple bit bus equipment, for detection purposes, all values in the protected word ranges shown in Table 6 should be considered equivalent to LSB and MSB in a given bit range.

Table 6: Protected words range in IR system 1 thru 5

Bit range	8 bit (hex)	10 bit (hex)	12 bit (hex)	14 bit (hex)	16 bit (hex)
MSB	FF	3FF	FFF	3FFF	FFFF
Protected words range	FF	3FC ~ 3FF	FF0 ~ FFF	3FC0 ~ 3FFF	FF00 ~ FFFF
Image data	NA	NA	NA	NA	NA
Protected words range	00	000 ~ 003	000 ~ 00F	0000 ~ 003F	0000 ~ 00FF
LSB	00	000	000	0000	0000

10 Ancillary data space

Ancillary data may be inserted in any portion of the data stream not occupied by timing reference signals or IR image data (including empty words) as shown in Figures 1 - 6.

Two categories of ancillary data, HANC and VANC, are defined for different portions of the data stream.

Note: The three-word header used to identify ancillary data is the same for HANC and VANC. HANC and VANC data packet format is governed by SMPTE ST 291-1[1].

10.1 Horizontal ancillary data (HANC data)

HANC data are permitted in all horizontal intervals, including vertical blanking interval, but not in the active portion of lines. Each packet of HANC data is preceded by the three-word ancillary data header:

000h 3FFh 3FFh

Note: Shown ancillary data header is for 10 bit system. For systems with a different number of bits, the header is changed accordingly to the selected bit system.

Multiple HANC packets of ancillary data may occur multiple times during each horizontal blanking period according to rules set forward in SMPTE ST 291-1[1]. All rules as defined in section 5 of SMPTE ST 291-1 on protected words must be observed by the inserted ancillary data packet header.

10.2 Vertical ancillary data (VANC data)

VANC data are permitted in all horizontal lines present during the vertical blanking interval for each IR system. Each packet of VANC data is preceded by the three-word ancillary data header:

000h 3FFh 3FFh

Note: Shown ancillary data header is for 10 bit system. For systems with different number of bits, the header is changed accordingly to the selected bit system.

Multiple ancillary data VANC packets may occur multiple times during each horizontal line present in the vertical blanking interval according to rules set forward in SMPTE ST 291-1. All rules as defined in section 5 of SMPTE ST 291-1 on protected words must be observed by the inserted ancillary data packet header.

11 Image coding characteristic

11.1 Quantization

Requirement	
RP 0402.6-17	The IR image data shall be uniformly-quantized, PCM binary encoded at 8, 10, 12, 14 or 16 bits per sample.
RP 0402.6-18	The scan of the IR image shall be of a progressive type, frame and line repetitive.

The sampling frequencies shown in Table 7 are nominal for a given IR system.

11.2 Coding parameters

Table 7: Coding parameters for IR image

Parameters	IR image frame frequency 60 Hz			IR image frame frequency 50 Hz	
IR system	1	2	4	3	5
Image Active Samples Line(H) x (Line (V)	640 x 480	720 x 480	1280 x 720	720 x 576	1280 x 720
Number of Samples in a Line	858	858	1650	864	1980
Sampling frequency	27.027MHz	27.027MHz	74.25MHz	27MHz	74.25MHz
Sampling Structure	Progressive scan, frame and line repetitive				
Coding Format	Uniformly quantized PCM at 8 or 10 or 12 or 14 or 16 bits				
Filter Template	A	A	B	A	B

Note: Filter templates for different IR systems shown in Annex A.

12 Coding bit range assignment

Requirement	
RP 0402.6-19	The range of the binary coding shall be as shown in MISB RP 0402.6 Table 8 according to its selected bit range.

Note: The range is selected such way that 0% signal level is constant and independent of selected number of bits for sampling.

Table 8: Digital range assignment for different word sizes on a parallel signal bus

Bit range	8-bit (hex)	10-bit (hex)	12-bit (hex)	14-bit (hex)	16-bit (hex)
Most Significant	FF (255)	3FF (1023)	FFF (4095)	3FFF (16383)	FFFF (65535)

Bit range	8-bit (hex)	10-bit (hex)	12-bit (hex)	14-bit (hex)	16-bit (hex)
Protected words range	FF (255)	3FC~3FF (1020~1023)	FF0~FFF (4080~4095)	3FC0~3FFF (16230~16383)	FF00~FFFF (65280~65535)
Overshoot words range	EC~FE (236~254)	3AD~3FB (941~1019)	EB1~FEF (3761~4079)	3AC1~3FBF 15041~16319)	EB01~FEFF 60161~65279)
100% White signal level	EB (235)	3AC (940)	EB0 (3760)	3AC0 (15040)	EB00 (60160)
0% Black signal level	10 (16)	40 (64)	100 (256)	400 (1024)	1000 (4096)
Undershoot words range	01~F (1~15)	04~3F (4~63)	010~0FF (16~255)	40~3FF (64~1023)	100~FFF (256~4095)
Protected words range	00 (0)	000~003 (0~3)	000~00F (0~15)	0000~003F (0~63)	0000~00FF (0~255)
Least Significant	00 (0)	000 (0)	0000 (0)	0000 (0)	0000 (0)

Note: The protected words ranges shown in Table 6 and Table 8 are necessary to assure proper synchronization of the resulting IR image stream.

Note: The Undershoot and Overshoot words provide dynamic range needed for potential overload.

13 Signal filtering (optional)

Conversions for direct viewing of the digital infrared image from the digital-to-analog domain presume post-filters that follow D/A conversion provide sin (x) / x correction complementary to the sin(x)/x filtering of the acquired image during the A/D digital conversion. This is most easily achieved if, in the design process, the pre and post filter is treated as a single unit.

It is recognized that pass-band tolerances for amplitude ripple and group delay are very tight; nevertheless, it is possible to design filters so that the specified characteristics are met in practice. Manufacturers are required to make every effort to assure that each filter meets the given requirements.

Filter templates for IR systems 1 through 5 identifying insertion loss, pass-band loss and group delay are available in Annex A.

14 Interface clock and jitter

14.1 Clock

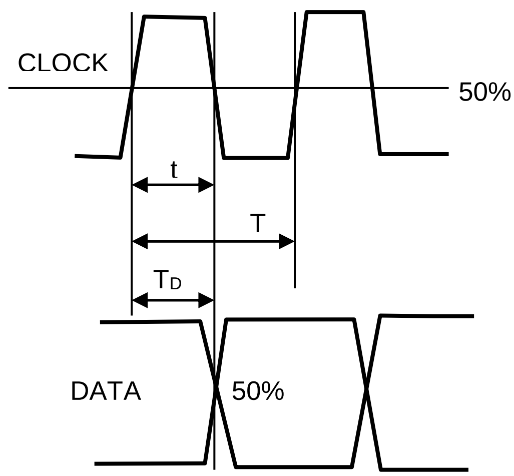
Requirement	
RP 0402.6-20	One pair of wires on the interface shall convey a clock signal at the sampling frequency with a positive pulse width of (0.5 ± 0.11) T 9 (see MISB RP 0402.6 Figure 8).

RP 0402.6-21	Data signals shall be asserted by the transmitter at a time interval (0.5 ± 0.075) T, denoted T_D, following the 0-to-1 transition of the clock (see MISB RP 0402.6 Figure 8).
RP 0402.6-22	Data signals "DATA (0-15)" shall be sampled at the receiver by the 0-to-1 transition of the clock.

14.2 Clock Jitter

Requirement	
RP 0402.6-23	Peak-to-peak jitter between rising edges of the transmitted clock shall be less than 0.08T measured over a period of one frame.

Note: This jitter specification, while appropriate for an effective parallel interface, may not be suitable for clocking digital-to-analog conversion or parallel-to-serial conversion.



Clock period: $T = 1/(C \times f_H)$ C = number of total words/line shown in table 1

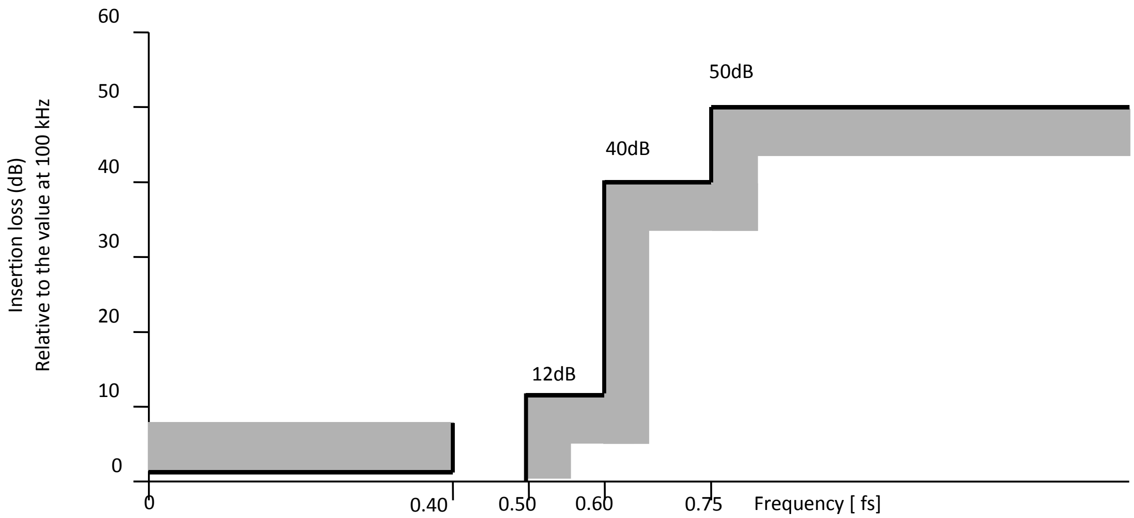
CLOCK pulse width: $t = (0.5 +/-0.11)\ T$ f_H = number of lines x number of frames/sec

DATA timing(at source): $T_D = (0.5 +/-0.075)\ T$

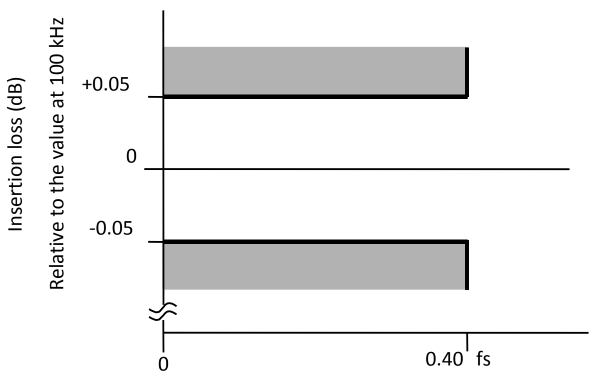
Figure 8: Interface Clock

15 Annex A - Filter Templates – Informative

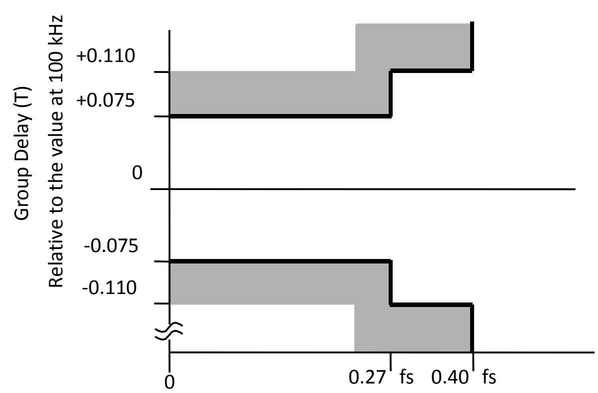
(See SMPTE ST 296[[4] Annex B)



Insertion loss



Pass-band ripple



Pass-band group-delay

Note: The value of fs for IR system 1 through 5 is given in Table 7

16 Annex B

16.1 Error detection and correction in the timing reference signal (SAV, EAV)

Table 9 enables single bit errors in the fourth bytes of EAV and SAV to be corrected. Double errors, and some multiple-bit errors, are detected but not corrected.

The table gives corrected values for bits 8, 7, and 6 where possible. Multiple errors are denoted by an “x”.

Table 9: Error Correction Table

Received bits P3 ~P0	Received bits F, V and H			
	000	001	010	011
0000	000	000	000	x
0001	000	x	x	111
0010	000	x	x	011
0011	x	x	010	x
0100	000	x	x	011
0101	x	001	x	x
0110	x	011	011	011
0111	100	x	x	011
1000	000	x	x	x
1001	x	001	010	x
1010	x	101	010	x
1011	010	x	010	010
1100	x	001	110	x
1101	010	001	x	001
1110	x	x	x	011
1111	x	001	010	x

17 Annex C – Informative

17.1 Method for establishing a back-level reference prior to digitizing

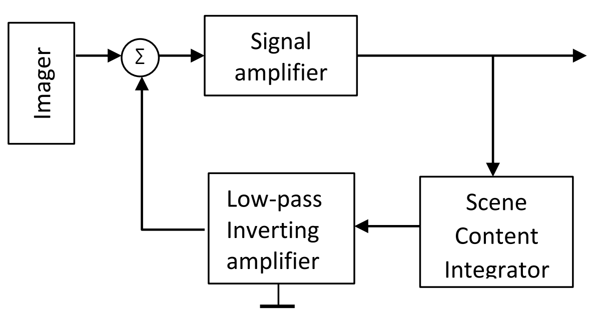
In digitizing an analog image signal it is important to establish a reference point. A reference point enables the efficient utilization of an A/D converter's range for optimal processing. In addition, where other sources may be switched into the signal path, a common operating point is required if they share a common digital range.

Image information provided by a EO visible light imager consists of many gray levels that form a picture or image. The lowest gray level corresponds to the lowest brightness of the scene; intermediate levels portray various details of a scene, and finally the highest gray levels represent the highest brightness. In addition, specular light is formed by a reflection from a shiny object (an example is the reflection from a highly polished surface of a metal or glass). These levels that describe an image signal may be also applicable to IR image with some exceptions. In most visible light scenes the background (lowest level) of the scene affects the overall brightness of the image; this reduces the dynamic range of the image viewed on the display device.

An IR imager does not depend on reflected light; instead it registers a wavelength out of a spectrum of frequencies invisible to the human eye, but always present. That means a signal from the IR imager is created by sensing energy that is radiated rather than reflected by an object. In an IR image the background level of a scene depends on the temperature of the background, which is proportional to the background level of the scanned IR image scene.

Interestingly, the average content of a scene has relatively low energy (DC component); the mid and high level components mostly consist of transitions with peaks and valleys. Therefore, if the DC component of the scene background is maintained at a constant point (without cutting off the "low" brightness" information), the operating point of the image can be stabilized and more favorable to subsequent digital processing.

One method to maintain a constant reference point at the lowest level (background) includes a scene content integrator and a low-pass inverting amplifier as shown below. The output signal is "averaged" by the scene content integrator and then some percentage of this average is subtracted from the input signal through signal inversion. This stabilizes the background point to the lowest (black) level of the IR scene.



Once a DC reference point is established, DC coupling is possible throughout the rest of the process chain. If AC signal coupling is used, a DC restoration circuit is necessary to recover the DC reference point prior digitizing.